STATEMENT

I, Makoto KONDO, of c/o NGB Corporation, ARK Mori Building 13F, 12-32, Akasaka 1-Chome, Minato-ku, Tokyo 107-6013 Japan, hereby state that I am conversant with both the English and Japanese languages and certify to best of my knowledge and belief that the attached is a true and correct English translation of the priority document of Japanese patent application 2003-009435 filed on January 17, 2003.

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[TITLE OF INVENTION] BRUSHLESS MOTOR

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[Title of Invention] Brushless Motor

[Claims]

[Claim 1]

A brushless motor comprising a fixedly-supported stator coil, a rotor including a yoke which supports a rotor magnet provided around the stator coil, and is connected to a rotation shaft, and a gear which is connected to the rotation shaft, and is in mesh with a gear mechanism; characterized in that the yoke and the gear are formed integrally with each other, and are made of a resin.

[Claim 2]

A brushless motor according to claim 1, characterized in that the yoke has a cylindrical container-shape, and the rotor magnet of an annular shape is mounted on an inner peripheral surface of the yoke, and the gear is formed integrally on a central portion of an outer end surface of the yoke, and a shaft hole is formed through the gear, and extends along a centerline of the gear, and the rotation shaft is passed through the shaft hole in a fitted condition.

[Detailed Description of the Invention]

[0001]

[Technical Field]

[0001]

This invention relates to a brushless motor, and more

particularly to a brushless motor which has a reduced number of component parts, and can be easily assembled, thereby achieving a low-cost and lightweight design.

[0002]

A brushless motor is not provided with a so-called commutator formed by brushes and a moving contact, and is advantageous in that it can be formed into a compact and lightweight construction. Such a brushless motor is used, for example, as a drive source of a rotation drive device for deflecting an optical axis of a vehicle lamp described in Patent Document 1. More specifically, Fig. 12 shows a cross-sectional view of a conventional outer rotor-type brushless motor (the related art). Identical reference numerals in this Figure and other Figures of preferred embodiments (described later) of the invention denote corresponding portions. A thrust bearing 421 and a sleeve bearing 422 are fitted in a hollow boss 414 formed on an equipment housing 41, and a rotation shaft 423 is rotatably inserted in this sleeve bearing 422. A stator coil 424 is fixedly mounted on the hollow boss 414, and is disposed above a printed circuit board 45 provided within the housing 41. A cylindrical container-like rotor 426 is mounted on the rotation shaft 423, and is rotatably disposed around the stator coil 424. In the stator coil 424, a plurality of coils 4243 are wound on a petal-like core 4241 in such a manner that these coils 4243 are arranged in a circumferential direction so as to produce

a plurality of magnetic poles in the circumferential direction. The core 4241 is fitted at its central hole 4244 on the outer periphery of the hollow boss 414, and therefore is supported by this hollow boss. Terminals 4243a of the coils 4243 are electrically connected to the printed circuit board 45, and an alternating current, for example, a three-phase alternating current, is supplied to these coils through the printed circuit board 45.

[0003]

[Patent Document 1] JP-A-2002-160581

[0004]

In the rotor 426, an annular rotor magnet 428 is mounted within a cylindrical container-like yoke 427 of metal, as shown in Fig. 13 which is an exploded, cross-sectional view. A plurality of S-poles and N-poles are alternately magnetized in the rotor magnetic 428 in a circumferential direction. The rotation shaft 423 is integrally connected to the yoke 427 through a bushing 4272 fitted in a central hole 4271 in this yoke. A gear 441 for transmitting a rotational force to the exterior is fixedly mounted on a distal end portion of the rotation shaft 423.

[0005]

In this brushless motor, when a three-phase current is supplied to the stator coil 424, S-poles and N-poles are alternately produced at a plurality of portions of the core 4241

of the stator coil 424 in the circumferential direction. Therefore, a magnetic force, produced between this stator core and the circumferentially-arranged S-poles and N-poles of the rotor magnet 428, changes in accordance with the phase of the three-phase current, and the rotor magnet 428 and the yoke 427, integrally connected thereto, are rotated by this magnetic force. When the yoke 427 thus rotates, the rotation shaft 423 rotates together with this yoke, so that the gear 441, fixedly mounted on the distal end portion of this rotation shaft, is rotated. In the brushless motor, the stator coil 424 for supplying electric power is fixed, and therefore there is no need to provide a commutator for changing the direction of a current flowing through the coils, and this is advantageous in achieving a compact and lightweight design of the motor.

[0006]

For assembling this conventional brushless motor, the stator coil 424, having the coils 4243 wound on the core 4241, is mounted on a predetermined portion of the printed circuit board 45, and then the terminals 424a of the coils 4243 are connected to electrodes on the printed circuit board 45 by soldering or the like, and the stator coil 424 is supported above the printed circuit board 45 in a floating condition. Then, the printed circuit board 45 is mounted within the housing 41. At this time, the stator coil 424 is fitted on the outer periphery of the hollow boss 414 of the housing 41. On the other hand,

in the rotor 426, the bushing 4272 is fitted into the central hole 4271 of the yoke 427 having the rotor magnet 428 mounted therein, and then the yoke is press-fitted on the rotation shaft 423 through the bushing 4272, and therefore is fixed to the rotation shaft 424, and then the gear 441 is press-fitted on the distal end portion of the rotation shaft 423. Then, the thrust bearing 421 and the sleeve bearing 422 are fitted into the hollow boss 414 from the upper side of the printed circuit board 45, and also the proximal end portion of the rotation shaft 423 is inserted into the sleeve bearing 422, so that the rotation shaft 423 is borne by these bearings. As a result, the rotor 426 is mounted in a manner to cover the stator coil 424, so that the assemblage of the brushless motor is completed.

[0007]

[Subject to be resolved by the invention]

In the conventional brushless motor, the rotor 426 comprises the yoke 427, the rotor magnet 428, the bushing 4272, and the gear 441, and therefore the number of the component parts is relatively large. And besides, when assembling the rotor 426, the bushing 4272 is press-fitted into the yoke 427 to be integrally connected thereto, and then the rotation shaft 423 is passed through the bushing 4272 in a press-fitted condition, and further the gear 441 is press-fitted on the rotation shaft 423 to be fixed thereto. Therefore, the operations, using press-fitting apparatus, are required, and much time and labor

are required for the assembling operation, and the overall cost, including the cost of the parts and the cost of the motor-assembling operation, increases, and therefore it is difficult to achieve the low cost-design of the motor. In addition, press-fitting margins for the purpose of press-fitting the parts need to be provided on the rotation shaft 423 in the axial direction, and therefore it is difficult to reduce the axial dimension of the rotation shaft. Furthermore, the bushing 4272, the yoke 427 and the gear 441 are made of metallic materials, respectively, and this is a barrier to the lightweight design. Particularly, the yoke 427, made of metal, has an increased weight, and therefore an inertia moment of the rotor 426 is liable to become large, which causes the vibration of the rotor when it rotates at high speed. Furthermore, when the precision of assembling of the bushing 4272, yoke 427 and gear 441 relative to the rotation shaft 423 is low, the yoke 427 and the gear 441 fail to rotate in a common plane relative to the rotation shaft 423, and this tends to invite a problem that the rotation balance is disturbed, so that rotation characteristics are lowered.

[0008]

It is another object of this invention to provide a brushless motor which has a reduced number of component parts, and can be easily assembled, thereby achieving a low-cost and lightweight design.

[0009]

[Means for resolving the problem]

According to the invention, there is provided a brushless motor comprising a fixedly-supported stator coil, a rotor including a yoke which supports a rotor magnet provided around the stator coil, and is connected to a rotation shaft, and a gear which is connected to the rotation shaft, and is in mesh with a gear mechanism; characterized in that the yoke and the gear are formed integrally with each other, and are made of a resin. In the brushless motor of the invention, preferably, the yoke has a cylindrical container-shape, and the rotor magnet of an annular shape is mounted on an inner peripheral surface of the yoke, and the gear is formed integrally on a central portion of an outer end surface of the yoke, and a shaft hole is formed through the gear, and extends along a centerline of the gear, and the rotation shaft is passed through the shaft hole in a fitted condition.

[0010]

In the invention, the yoke of the rotor and the gear in the brushless motor are formed integrally with each other, using the resin, and these are supported on the rotation shaft in a fitted condition. Therefore, the number of the component parts of the rotor is reduced, and the time and labor, required for assembling the rotor, are reduced. As a result, the cost of the parts and the cost of the assembling operation are reduced,

so that the low-cost design of the motor can be achieved. And besides, press-fitting margins for the purpose of press-fitting the relevant parts do not need to be provided on the rotation shaft, and therefore the axial dimension of the rotation shaft can be reduced, which is advantageous in achieving the compact design. Furthermore, the yoke and the gear are made of the resin, and therefore the lightweight design can be achieved, and this also prevents the vibration during the high-speed rotation, so that a rotation balance can be improved, thereby enhancing the rotation characteristics.

[0011]

[Mode for Carrying out the Invention]

Next, an exemplary embodiment in which the brushless motor according to the present invention is applied to an Adaptive Front-lighting System (AFS) of a vehicle will be described. In an AFS, information representative of a running condition of an automobile CAR is detected by sensors 1, and detection outputs of these sensors are sent to an electronic control unit (hereinafter referred to as "ECU") 2 as shown in Fig. 1 which is a conceptual view. For example, as the sensors 1, there are provided a steering sensor 1A for detecting a steering angle of a steering wheel SW of the automobile CAR, a speed sensor 1B for detecting the speed of the automobile CAR, and leveling sensors 1C (only the sensor for a rear axle is shown) for respectively detecting the heights

(or levels) of the front and rear axles so as to detect a horizontal condition (leveling) of the automobile CAR. These sensors 1A, 1B and 1C are connected to the ECU 2. In accordance with the outputs of the sensors 1 inputted thereto, the ECU 2 controls swivel lamps 3R and 3L (that is, headlamps 3 each capable of deflecting an illuminating direction right and left to change its luminous distribution characteristics) provided respectively at right and left portions of the front of the automobile. In one known example of such swivel lamp 3R, 3L, a reflector and a projector lamp are provided within the headlamp, and can be angularly moved in a horizontal direction, and these are driven for rotation by a drive power source (such as a drive motor) through rotation drive means. Here, a mechanism, including this rotation drive source, is referred to as an actuator. When a car travels along a curved road, this kind of AFS enables the headlamps to illuminate a road ahead of the curve in accordance with the running speed of the car, and therefore the AFS is effective in enhancing the running safety.

[0012]

Fig. 2 is a vertical cross-sectional view of a headlamp 3 (comprising a swivel lamp 3R, 3L capable of deflecting an illuminating direction right and left, the swivel lamp being a constituent element of an AFS serving as lamp deflection angle control means of the invention), showing an internal structure

thereof, and Fig. 3 is a partly-exploded, perspective view of a main portion thereof. A lens 12 is attached to a front open portion of a lamp body 11, and a rear cover 13 is attached to a rear open portion thereof, thereby forming a lamp chamber 14. A projector lamp 30 is provided within the lamp chamber 14. The projector lamp 30 comprise a sleeve 301, a reflector 302, a lens 303, and a light source 304 which are combined together into a unit. This kind of projector lamp has already been extensively used, and therefore detailed description thereof will be omitted here. A discharge bulb is used as the light source 304. The projector lamp 30 is supported by a generally U-shaped bracket 31. An extension 15 is provided around the projector lamp 30 in the lamp body 11 to prevent the interior of the lamp from being viewed through the lens 12. In this embodiment, a lighting circuit 7 for lighting the discharge bulb 304 of the projector lamp 30 is mounted in the lamp by the use of a lower cover 16 attached to a lower open portion of the lamp body 11.

[0013]

The projector lamp 30 is supported by the bracket 31 in such a manner that this projector lamp is interposed between a lower plate 312 and an upper plate 313 which extend substantially perpendicularly from a vertical plate 311 of the bracket 31. An actuator 4 (described later) is fixedly secured to a lower side of the lower plate 312 by screws 314, and a

rotation output shaft 448 of the actuator 4 projects upwardly through a shaft hole 315 formed through the lower plate 312. The screws 314 are screw-fastened respectively to bosses 318 formed on the lower surface of the lower plate 312. A shaft portion 305, formed on an upper surface of the projector lamp 30, is fitted in a bearing 316 provided on the upper plate 313, and a connecting portion 306, provided on a lower surface of the projector lamp 30, is fitted on the rotation output shaft 448 of the actuator 4, and is connected thereto. With this construction, the projector lamp 30 can be angularly moved right and left relative to the bracket 31, and when the actuator 4 is operated, the projector lamp 30 is angularly moved in a horizontal direction together with the rotation output shaft 448.

[0014]

Aiming nuts 321 and 322 are fixedly mounted respectively on upper left and right portions of the bracket 31 (as viewed from the front side), while a leveling bearing 323 is fixedly mounted on a lower left portion of the bracket. A horizontal aiming screw 331 and a vertical aiming screw 332, which are threadably supported on the lamp body 11, are threaded into the aiming nuts 321 and 322, respectively. A leveling ball 51 of a leveling mechanism 5, supported on the lamp body 11, is fitted in the leveling bearing 323. With this construction, by threading the horizontal aiming screw 331, the bracket 31 can

be angularly moved in the horizontal direction about an axis passing through the right aiming nut 322 and the leveling bearing 323. By threading the horizontal aiming screw 331 and the vertical aiming screw 332 at the same time, the bracket 31 can be angularly moved upward and downward about the leveling bearing 323. When the leveling mechanism 5 is operated, the leveling ball 51 is moved forward and backward in an axial direction, and by doing so, the bracket 31 can be angularly moved upward and downward about an axis passing through the left and right aiming nuts 321 and 322. With this construction, the aiming adjustments for adjusting the optical axis of the projector lamp 30 in the left and right directions and the upward and downward directions can be effected, and also there can be effected the leveling adjustment for adjusting the optical axis of the projector lamp in the upward and downward directions in accordance with a leveling condition changing with a change of a car height. A projection 307 is formed on a lower surface of the reflector 302 of the projector lamp 30, and a pair of stamped-out stoppers 317 are formed respectively at left and right sections of that portion of the lower plate 312 (of the bracket 31) generally opposed to the projection 307. When the projector lamp 30 is angularly moved, the projection 307 is brought into engagement with one of the stoppers 317, thereby limiting the range of angular movement of the projector lamp 30.

[0015]

Fig. 4 is an exploded, perspective view of a main portion of the actuator 4 for swiveling the swivel lamp 3R, 3L, and Fig. 5 is a plan view showing the construction of the actuator in its assembled condition, and Fig. 6 is a vertical cross-sectional view thereof. A casing 41 is formed by a lower half portion 41D and an upper half portion 41U each having a generally-pentagonal dish-like shape. A plurality of projections 410, formed on a peripheral surface of the lower half portion 41D, are fitted respectively in a plurality of fitting piece portions 411 extending downwardly from a peripheral surface of the upper half portion 41U, so as to forming a casing room. In addition, support piece portions 412, 413 are formed on and project from side surfaces of the upper half portion 41U and side surfaces of the lower half portion 41D, respectively. These support piece portions 412 and 413 are used to fix the casing 41 to the bracket 31 through the screws 314 as described above. The rotation output shaft 448, having splines, projects from the upper surface of the casing 41, and is connected to the connecting portion 306 provided at the bottom surface of the projector lamp 30. A connector 451 is provided at a bottom side of the casing 41. An external connector 21 (see Figs. 2 and 3), connected to an ECU2, is adapted to be fittingly connected to this connector 451.

[0016]

Four hollow bosses 414, 415, 416 and 417 are formed upright respectively on predetermined portions of an inner bottom surface of the lower half portion 41D of the casing 41. A brushless motor 42 (described later), serving as a drive motor, is assembled on the first hollow boss 414. Shafts of a gear mechanism 44 (described later) are inserted and supported in the second to fourth hollow shafts 415, 416 and 417, respectively. A step-like rib 418 is formed integrally on a peripheral edge portion of the inner bottom surface of the lower half portion 41D over an entire periphery thereof, and a printed circuit board 45 is placed at its peripheral edge portion on the step-like rib 418, and the printed circuit board 45 is mounted and supported within the casing 41 in such a manner that this printed circuit board 45 is held between the step-like rib 418 and a downwardly-directed rib (not shown) formed on the upper half portion 41U. The first hollow boss 414 passes through the printed circuit board 45, and the assembled brushless motor 42 is electrically connected to the printed circuit board 45, and various electronic parts (not shown) of a control circuit 43 (described later) and the connector 451 are mounted on the printed circuit board 45.

[0017]

In the brushless motor 42, as shown in FIG. 4, a rotation shaft 423 is rotatably supported in the first hollow boss 414 of the lower half portion 41D through a thrust bearing 421 and

a sleeve bearing 422. A stator coil 424, including three pairs of coils equally spaced in a circumferential direction, is fixedly mounted on the printed circuit board 45 which is supported on the lower half portion 41D, with the first hollow boss 414 passing therethrough. The stator coil 424 is electrically connected to the printed circuit board 45 so as to be supplied with electric power. Here, the stator coil 424 is integrally combined with a core base 425, and is electrically connected to the printed circuit board 45 via terminals 425a formed at the core base 425. A cylindrical container-like rotor 426 is fixedly mounted on an upper end portion of the rotation shaft 423 in surrounding relation to the stator coil 424. The rotor 426 comprises a resin-molded yoke 427 of a cylindrical container-shape, and an annular rotor magnet 428 which is mounted on an inner surface of the yoke 427, and has S-poles and N-poles alternately magnetized therein in a circumferential direction. Although the yoke 427 is molded of a phenolic resin, it can be molded of a PBT (polybutylene terephthalate) resin or a PPS (polyphenylene sulfide) resin.

[0018]

Fig. 7 is a partly-exploded, perspective view showing the stator coil 424 and the core base 425, and Fig. 8 is a partly-broken, partly-exploded perspective view of the rotor 426. Fig. 9 is a cross-sectional view of the brushless motor 42 incorporating the stator coil 424. The stator coil 424

includes a petal-like core 4241 having 6 radial arms 4242, and the coils 4243 are wound on the radial arms 4242, respectively. Each pair of diametrically-opposite coils 4243 are serially connected, so that the three pairs of coils are provided. Three fitting grooves 4245 are formed in an inner surface of a central hole 4244 in the core 4241, and are spaced from one another in a circumferential direction, and extend in an axial direction, each fitting groove 4245 being recessed toward the outer periphery of the core.

[0019]

The core base 425 includes an annular portion 4251, and three narrow fitting support piece portions 4252 are formed integrally with and project axially from one surface of the annular portion 4251, and are circumferentially spaced from one another. Three short support seats 4253 are formed integrally with and project axially from the one surface of the annular portion 4251, the support seat 4253 being provided between any two adjacent fitting support piece portions 4252. A hook 4254 is formed at a distal end of each fitting support piece portion 4252, and the fitting support piece portions 4252, when passed through the central hole 4244 in the core 4241, are fitted respectively in the fitting grooves 4245, respectively, and the hooks 4254 are engaged with one edge of the core 4241, so that the core 4241 is held between the hooks 4254 and the support seats 4253, thereby integrally combining the core base 425 and

the stator coil 424 together. Two legs 4255 are formed integrally with and project axially respectively from two of six circumferentially-equally-divided sections of the other surface of the annular portion 4251 of the core base 425, and the terminals 425a, each comprising an electrically-conductive wire (metal wire) having a bent portion, extend respectively through the other four sections of the annular portion 4251, and are supported by this annular portion 4251, and distal end portions of the terminals 425a project from the annular portion 4251. Recesses 4256 are formed respectively in the inner peripheral surface of the core base, and are disposed respectively at those portions of the core base through which the terminals 425a extend, respectively. Those portions of the annular portion 4251, in which the recesses 4256 are formed, respectively, are radially reduced in thickness. Three terminals 425a1 to 425a3 (disposed adjacent to one another in the circumferential direction) among the four terminals 425a are provided as separate terminals, respectively, and a terminal 4243a of one of each pair of coils 4243 is electrically connected by soldering to a proximal end of the corresponding terminal 425a1, 425a2, 425a3. The remaining terminal 425a4 serves as a common terminal, and a terminal 4243a of the other of each pair of coils 4243 is electrically connected to a proximal end of this common terminal by soldering.

[0020]

When the fitting support piece portions 4252 of the core base 425 (which is separate from the stator coil 424) are passed respectively through the fitting grooves 4245 in the core 4241, the hooks 4254 of the fitting support piece portions 4252 are engaged with the one edge of the core 4241, so that the core 4241 is held between the support seats 4253 on the core base 425 and the hooks 4254, thereby integrally combining the core base and the core together. At this time, the support seats 4253 are held against the other end or edge of the core 4241, thereby positioning the core 4241 relative to the core base 425. The terminals 4243a of the three pairs of coils 4243 are electrically connected to the three separate terminals 425a1 to 425a3 and one common terminal 425a4, and then the distal end portions of the terminals 425a1 to 425a4 are passed respectively through holes 452 in the printed circuit board 45 until the two legs 4255 are brought into contact with the surface of the printed circuit board 45. Then, the distal end portions of these terminals are soldered to circuit electrodes on the reverse surface of the printed circuit board 45. By doing so, the core base 425 is mounted on the printed circuit board 45, and the electrical connection to the coils 4243 is effected. As a result, the core base 425 is fixedly supported on the printed circuit board 45 in such a manner that the core base 425 is positioned relative to the printed circuit board 45 through the legs 4255. Also, the stator coil 424 is stably supported in

such a manner that the stator coil 424 is positioned relative to the printed circuit board 45, and in this condition, the stator coil can be supplied with electric power via the printed circuit board 45.

[0021]

In this embodiment, the distal end portions of the three separate terminals 425a1 to 425a3 are soldered to the printed circuit board 45, but the solders on the distal end portions of these terminals will not be melted since the terminals of the coils are soldered to the proximal ends of these terminals 425a1 to 425a3. The single common terminal 425a4 to which the terminals of the coils are electrically connected does not need to be connected to an external portion, and therefore is not soldered to the printed circuit board 45. Therefore, a solder-melting problem is not encountered even when the terminals of the three coils are soldered to the distal end portion of the common terminal 425a4. Even when a stress is transmitted from the printed circuit board 45 to the terminals 425a1 to 425a4 after the soldering, this stress will not adversely affect the stator coil 424 through the annular portion 4251 since those portions of the annular portion 425 through which the terminals pass, respectively, are reduced in thickness by the recesses 4256.

[0022]

On the other hand, the rotor 426, fixedly mounted on the

upper end portion of the rotation shaft 423, is disposed to cover the outer periphery and upper side of the stator coil 424 as shown in Figs. 4 and 8. As described above, the rotor 426 comprises the resin-molded yoke 427 of a cylindrical container-shape, and the annular rotor magnet 428 which is mounted on the inner surface of the yoke 427, and has the S-poles and N-poles alternately magnetized therein in the circumferential direction. A first gear 441 of the gear mechanism 44 (described later) is formed integrally with and projects from a central portion of a circular outer surface of the yoke 427, and the rotation shaft 423 is fitted in a shaft hole 4270, formed through the first gear 441, and is integrally combined therewith.

[0023]

As shown in Fig. 7, a plurality of (three in this embodiment) Hall elements or Hall ICs (hereinafter referred to as "Hall ICs") H1, H2 and H3 are mounted on the printed circuit board 45, and are arranged at predetermined intervals in the direction of the circumference of the rotor 426. When the rotor magnet 428 rotates together with the rotor 426, a magnetic field at each of the Hall ICs H1, H2 and H3 is changed, and each Hall IC H1, H2, H3 is changed between an ON-state and an OFF-state, and outputs a pulse signal corresponding to a rotation period of the rotor 426.

[0024]

The first gear 441, resin-molded integrally with the yoke 427 of the rotor 426, forms part of the gear mechanism 44, and is designed to drive and rotate the rotation output shaft 448 in a speed-reducing manner. Namely, the gear mechanism 44 includes the first gear 441, a second gear 443 rotatably mounted on a first fixed shaft 442 supported in the second hollow boss 415, a third gear 445 rotatably mounted on a second fixed shaft 444 supported in the third hollow boss 416, and a sector gear 447 which is rotatably supported on a third fixed shaft 446 supported in the fourth hollow boss 417, and is formed integrally with the rotation output shaft 448. Each of these gears is molded of a resin. As shown in Figs. 5 and 6, the second gear 443 includes a second larger-diameter gear 443a and a second smaller-diameter gear 443b which are integrally formed with each other, and are arranged in an axial direction, the second larger-diameter gear 443a being in mesh with the first gear 441. The third gear 445 includes a third larger-diameter gear 445a and a third smaller-diameter gear 445b which are integrally formed with each other, and are arranged in an axial direction, the third larger-diameter gear 445a being in mesh with the second smaller-diameter gear 443b. The third smaller-diameter gear 445b is in mesh with the sector gear 447. With this construction, a rotational force of the first gear 441, rotating together with the rotor 427 of the brushless motor 42, is reduced through the second gear 443, the third gear 445

and the sector gear 447, and is transmitted to the rotation output shaft 448. Stoppers 419 are formed on and project from the inner surface of the lower half portion 41D, and are disposed respectively at opposite ends of a path of rotation of the sector gear 447, and opposite ends of the sector gear 447 can be brought into abutting engagement with the stoppers 491, respectively. These stoppers 419 limit the range of angular movement of the sector gear 447 and hence the range of angular movement of the rotation output shaft 448.

[0025]

Fig. 10 is a block diagram of the electric circuit of the lighting unit including the ECU 2 and the actuator 4. The actuator 4 is provided in each of the right and left swivel lamps 3R and 3L of the car, and a two-way communication can be effected between the actuator 4 and the ECU2. The ECU 2 includes a main CUP 201 for effecting a processing on the basis of information from the sensors 1 according to a predetermined algorithm to output a required control signal C0, and an interface (hereinafter referred to as "I/F") circuit 202 for inputting and outputting the control signal CO between the main CPU 201 and the actuator 4. An ON/OFF signal from a lighting switch S1, provided at the car, can be inputted into the ECU 2, and in accordance with the ON/OFF state of the lighting switch S1, the ECU 2 controls the lighting circuit 7 (connected to an on-vehicle power source (not shown) so as to supply electric

power to the discharge bulb 304 of the projector lamp 30) by a control signal N so as to turn on and off the swivel lamp 3R, 3L. The ECU 2 controls a leveling control circuit 6 (for controlling the leveling mechanism 5 for adjusting the optical axis of the bracket (supporting the projector lamp 30) in the upward-downward direction) by a leveling signal DK so as to adjust the optical axis of the projector lamp 30 in accordance with a change of the car height. Naturally, the condition of connection of these electric circuits to the power source is turned on and off by an ignition switch S2 for turning on and off an electric system provided at the car.

[0026]

The control circuit 43, provided on the printed circuit board 45 contained in the actuator 4 mounted in each of the right and left swivel lamps 3R and 3L of the car, includes an I/F circuit 432 for inputting and outputting a signal between the control circuit 43 and the ECU 2, a sub-CPU 431 for effecting a processing on the basis of a signal from the I/F circuit 432 and pulse signals from the Hall ICs H1, H2 and H3 according to a predetermined algorithm, and a motor drive circuit (rotation drive means) 434 for driving and rotating the brushless motor 42. The ECU 2 outputs a right-left deflection angle signal DS (which is part of the control signal CO) representative of a right-left deflection angle of the swivel lamp 3R, 3L, and this signal is inputted to the actuator 4.

[0027]

Fig. 11 is a circuit diagram schematically showing the motor drive circuit 434 of the control circuit 43 and the brushless motor 42 in the actuator 4. The motor drive circuit 434 includes a switching matrix circuit 435, and an output circuit 436. As control signals, a speed control signal V, a start/stop signal S and a normal/reverse rotation signal R from the sub-CPU 431 of the control circuit 43, as well as pulse signals from the three Hall ICs H1, H2 and H3, are inputted into the switching matrix circuit 435. The output circuit 436 is responsive to an output of the switching matrix circuit 435 to adjust the phases of three-phase (U-phase, V-phase and W-phase) electric powers which are to be supplied respectively to the three pairs of coils of the stator coil 424 of the brushless motor 42. In this motor drive circuit 434, the U-phase, V-phase and W-phase powers are supplied to the stator coil 424, thereby rotating the rotor magnet 428, and therefore the yoke 427 (integral with this rotor magnet), that is, the rotor 426 and the rotation shaft 423, rotate. When the magnet rotor 428 rotates, the Hall ICs H1, H2 and H3 detect a change of the magnetic field to output pulse signals P, respectively, and these pulse signals P are inputted into the switching matrix circuit 435, and in this switching matrix circuit 435, a switching operation for the output circuit 436 is effected in accordance with the timings of the pulse signals, so that the

rotor 426 continues to rotate.

[0028]

In accordance with the speed control signal V, the start/stop signal S and the normal/reverse rotation signal R from the sub-CPU 431, the switching matrix circuit 435 feeds a required control signal C1 to the output circuit 436. In response to this control signal C1, the output circuit 436 adjusts the phases of the three-phase powers (which are to be supplied to the stator coil 424), and controls the start and stop of the rotation of the brushless motor 42, the direction of rotation thereof and the speed of rotation thereof. Part of each of the pulse signals P, outputted respectively from the Hall ICs H1, H2 and H3, is inputted into the sub-CPU 431, so that this sub-CPU recognizes the rotating condition of the brushless motor 42. An up-down counter 437 is contained in the sub-CUP 431, and the pulse signals from the Hall ICs H1, H2 and H3 are counted, so that the value of this count corresponds to the rotational position of the brushless motor 42.

[0029]

In the above construction, when the ignition switch S2 is turned on, and also the lighting switch S1 is turned on, information, representing the steering angle of the steering wheel SW, the speed of the car, the car height of the car, etc., is inputted into the ECU 2 from the sensors 1 mounted on the car as shown in Fig. 1. In the ECU 2, the main CPU 201 effects

a computing operation on the basis of the sensor outputs inputted thereto, and computes the right-left deflection angle signal DS of the projector lamp 30 of each of the swivel lamps 3R and 3L of the car, and these signals DS are inputted respectively to the actuators 4 of the two swivel lamps 3R and 3L. In the actuator 4, the sub-CPU 431 effects a computing operation on the basis of the right-left deflection angle signal DS inputted thereto, and computes a signal corresponding to this right-left deflection angle signal DS, and this computed signal is fed to the motor drive circuit 434, thereby driving and rotating the brushless motor 42. A rotation drive force of the brushless motor 42 is reduced in speed by the reduction gear mechanism 44, and is transmitted to the rotation output shaft 448. Therefore, the projector lamp 30, connected to the rotation output shaft 448, is angularly moved in the horizontal direction, so that the optical axis of the swivel lamp 3R, 3L is deflected right and left. When the projector lamp 30 is thus angularly moved, the angle of deflection of the projector lamp 30 is detected by the angle of rotation of the brushless motor 42. Namely, the sub-CPU 431 detects this deflection angle on the basis of the pulse signals P (P1, P2 and P3) outputted from the three Hall ICs H1, H2 and H3 provided at the brushless motor 42 as shown in Fig. 10. Further, the sub-CPU 431 compares the right-left deflection angle signal DS, inputted thereto from the ECU2, with a detection signal representative of the detected

deflection angle, and effects a feedback control of the rotation angle of the brushless motor 42 so that the two can coincide with each other, and by doing so, the optical axis of the projector lamp 30, that is, the optical axis of the swivel lamp 3R, 3L, can be highly precisely brought into a deflection position set by the right-left detection angle signal DS.

[0030]

In this deflecting operation for the projector lamp 30, deflected light, emitted from the swivel lamp 3R, 3L, illuminates a zone deflected right or left from a direction of straight travel of the car, and therefore during the travel of the car, each lamp can illuminate a zone ahead of the car not only in the direction of straight travel of the car but also in a direction toward which the car is steered, and therefore the driving safety can be enhanced.

[0031]

As described above, in the brushless motor 42 serving as the drive source for effecting the deflecting operation of each swivel lamp 3R, 3L, the resin-molded yoke 427 of the rotor 426 has a cylindrical container-like shape, and the annular rotor magnet 428 is mounted on the inner peripheral surface of this yoke, and the first gear 441 of the gear mechanism 44 is formed integrally with and projects from the central portion of the circular outer surface of the yoke 427, and the rotation shaft 423 is fitted in the shaft hole 4270, thereby providing the

unitary construction. Therefore, as compared with the conventional brushless motor of Fig. 12 in which the yoke 427, the bushing 4272 and the gear 441 are provided as separate parts, respectively, such parts can be provided by one resin-molded part. In the assembling of the rotor 426, the step of mounting the rotor magnet 428 on the inner peripheral surface of the yoke 427 is the same as in the conventional construction. However, thereafter, it is only necessary to merely fit the rotation shaft 423 in the shaft hole in the yoke 427, and the press-fitting operations, heretofore required for assembling the bushing 4272, the yoke 427 and the gear 423 together, are not necessary.

[0032]

Here, the fitting portions of the rotation shaft 423 and the shaft hole portion 4270 of the yoke 427 have the spline structure, and with this construction the operation for fitting the rotation shaft 423 into the yoke 427 can be effected more easily. Also, by insert-molding the rotation shaft 423 directly in the yoke 427, this fitting operation can be omitted. Therefore, the overall cost, including the cost of the parts and the cost of the brushless motor-assembling operation, can be reduced, thereby achieving the low cost-design of the brushless motor. In addition, press-fitting margins for the purpose of press-fitting the relevant parts do not need to be provided on the rotation shaft 423, and therefore the axial dimension of the rotation shaft can be reduced, which is

advantageous in achieving the compact design. Furthermore, the yoke 427 and the first gear 441 are made of the resin, and therefore the lightweight design can be achieved, and this prevents the vibration during the high-speed rotation. Furthermore, the yoke 427 can be supported on the rotation shaft 423 merely by press-fitting this single yoke 427 on the rotation shaft 423, and therefore the assembling precision can be enhanced, and the rotation balance of the rotor can be improved, thereby enhancing the rotation characteristics.

[0033]

Even though the yoke 427 is made of the resin, the rotation characteristics, not inferior to those of the conventional brushless motor with the metallic yoke, can be obtained by the use of the rotor magnet 428 having a high magnetic field intensity.

[0034]

In the above embodiments, although the brushless motor of the invention is used as the actuator for driving the swivel lamp of the AFS, the brushless motor can be used for other purposes.

[0035]

[Advantage of the Invention]

In the invention, the yoke of the rotor and the gear are formed integrally with each other, using the resin, and these are supported on the rotation shaft in a fitted condition.

Therefore, the number of the component parts of the rotor is reduced, and the time and labor, required for assembling the rotor, are reduced. As a result, the cost of the parts and the cost of the assembling operation are reduced, so that the low-cost design of the motor can be achieved. And besides, press-fitting margins for the purpose of press-fitting the relevant parts do not need to be provided on the rotation shaft, and therefore the axial dimension of the rotation shaft can be reduced, which is advantageous in achieving the compact design. Furthermore, the yoke and the gear are made of the resin, and therefore the lightweight design can be achieved, and this also prevents the vibration during the high-speed rotation, so that a rotation balance can be improved, thereby enhancing the rotation characteristics.

[Brief Description Of the Drawings]

[Fig. 1]

Fig. 1 is a view showing a conceptual construction of an AFS.

[Fig. 2]

Fig. 2 is a vertical cross-sectional view of a swivel lamp.

[Fig. 3]

Fig. 3 is an exploded, perspective view showing an internal structure of the swivel lamp.

[Fig. 4]

Fig. 4 is a partly-exploded, perspective view of an

actuator.

[Fig. 5]

Fig. 5 is a plan view of the actuator.

[Fig. 6]

Fig. 6 is a vertical cross-sectional view of the actuator.

[Fig. 7]

Fig. 7 is a partly-exploded, perspective view of a stator coil.

[Fig. 8]

Fig. 8 is a partly-broken, exploded perspective view of a rotor.

[Fig. 9]

Fig. 9 is a cross-sectional view showing an important portion of a brushless motor.

[Fig. 10]

Fig. 10 is a block circuit diagram showing a circuit construction of the AFS.

[Fig. 11]

Fig. 11 is a circuit diagram showing a circuit construction of the actuator.

[Fig. 12]

Fig. 12 is a cross-sectional view of a portion of a conventional brushless motor.

[Fig. 13]

Fig. 13 is an exploded, perspective view of a rotor of

the conventional brushless motor.

[Description of Reference Numeral]

1 a sensor

2 an ECU

3 a headlamp

3L and 3R swivel lamps

4 an actuator

5 a leveling mechanism

7 a lighting circuit

42 a brushless motor

44 a gear mechanism

423 a rotational shaft

424 a stator coil

425 a core base

426 a rotor

427 a yoke

441 a first gear

H1 H2 and H3 Hall ICs

S1 an ignition switch

S2 a lighting switch.

[Designation of Document] Abstract

[Abstract]

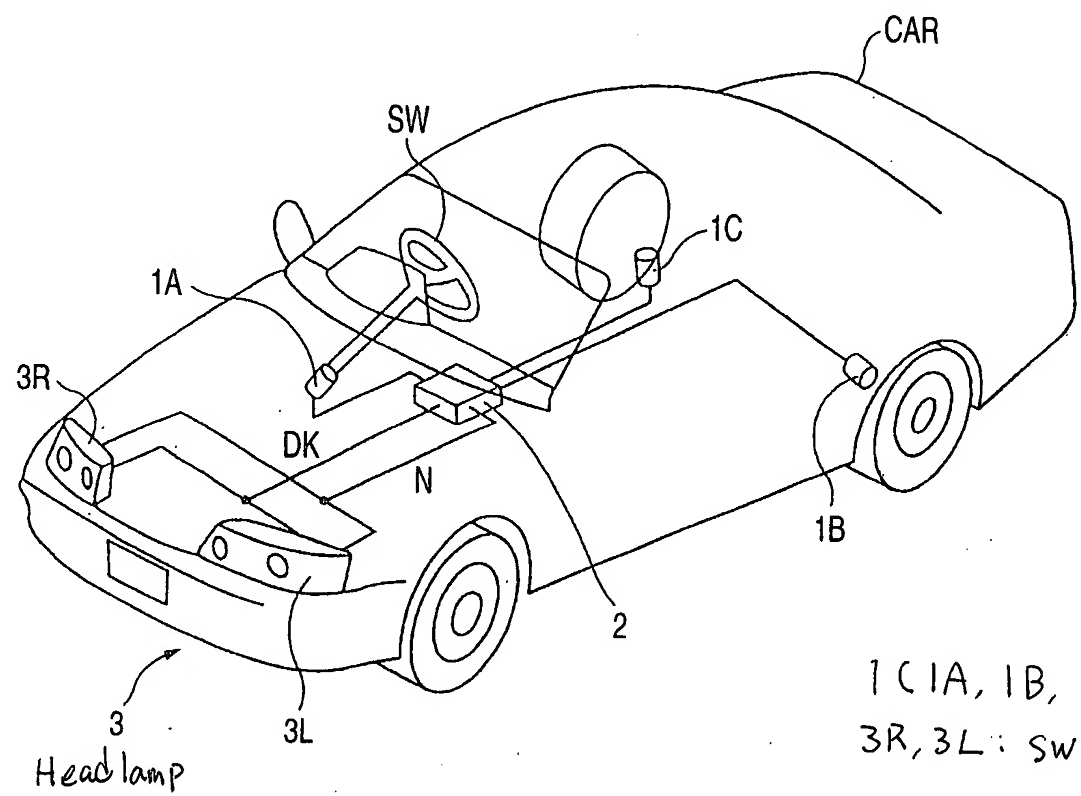
[Subject] By reducing a number of component parts and enabling easily assembling a brushless motor including a rotor and a stator, achieving a low-cost and lightweight design.

[Means for Resolution] In a brushless motor provided with a fixedly-supported stator coil 424, a rotor 426 including a yoke 427 which supports a rotor magnet 428 provided around the stator coil, and a gear 441 connected to the rotation shaft 423 so as to be in mesh with a gear mechanism, the yoke 427 is made of resin to be a cylindrical container-shape and the gear 441 is formed integrally on a central portion of an outer end surface of the yoke 427. A rotor magnet 428 is mounted on an inner peripheral surface of the yoke 427, and a rotational shaft 423 is fitted to the gear 441. Since the yoke 427 and the gear 441 are integrally formed of resin and supported by being fitted on the rotational shaft 423, a number of components of the rotor 426 is reduced so that an assembling manpower is reduced.

[Selected Drawing] Fig. 9

2003-009435

FIG. 1



1 (1A, 1B, 1C) : sensor
3R, 3L : swivel lamp

FIG. 2

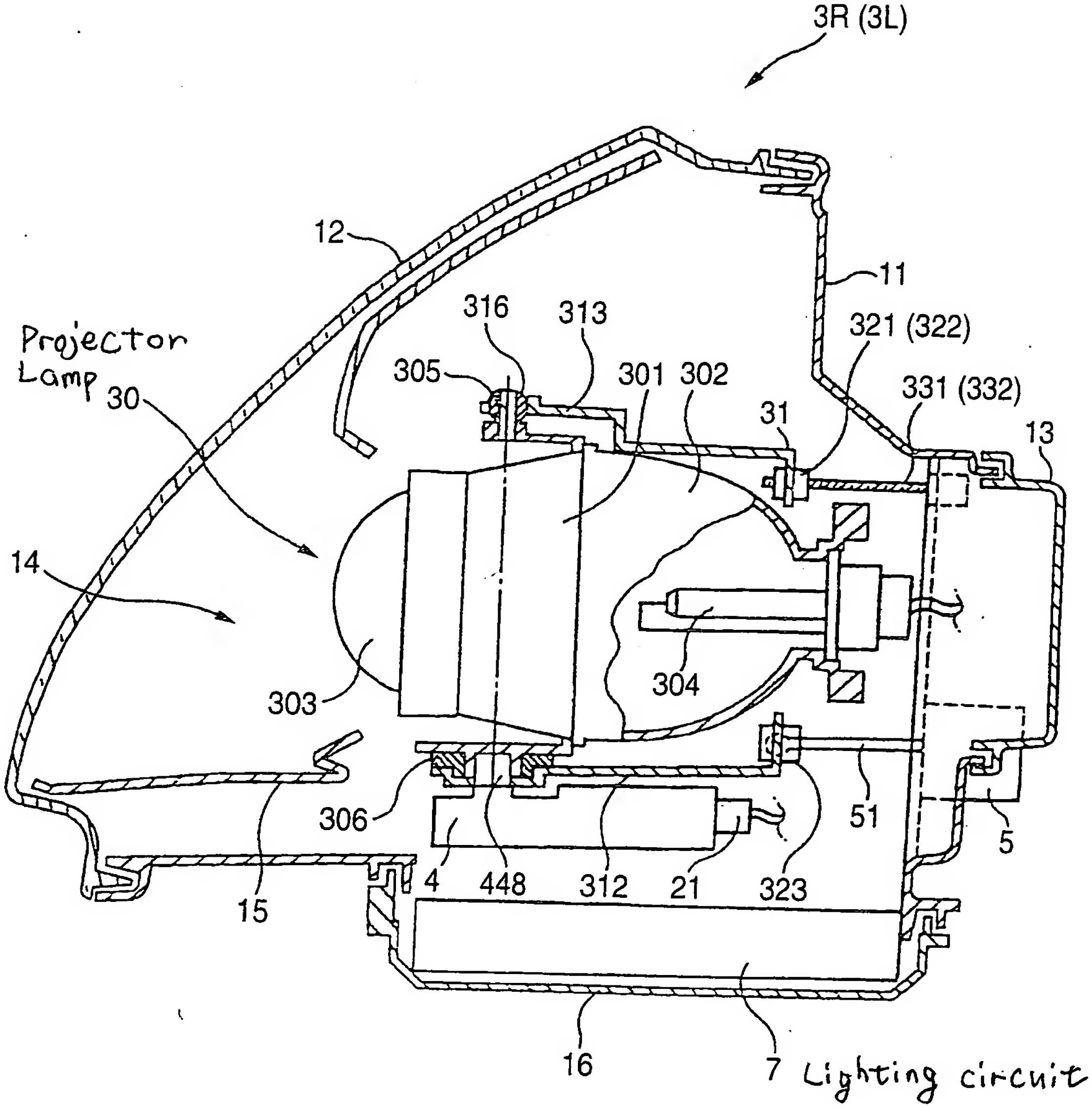
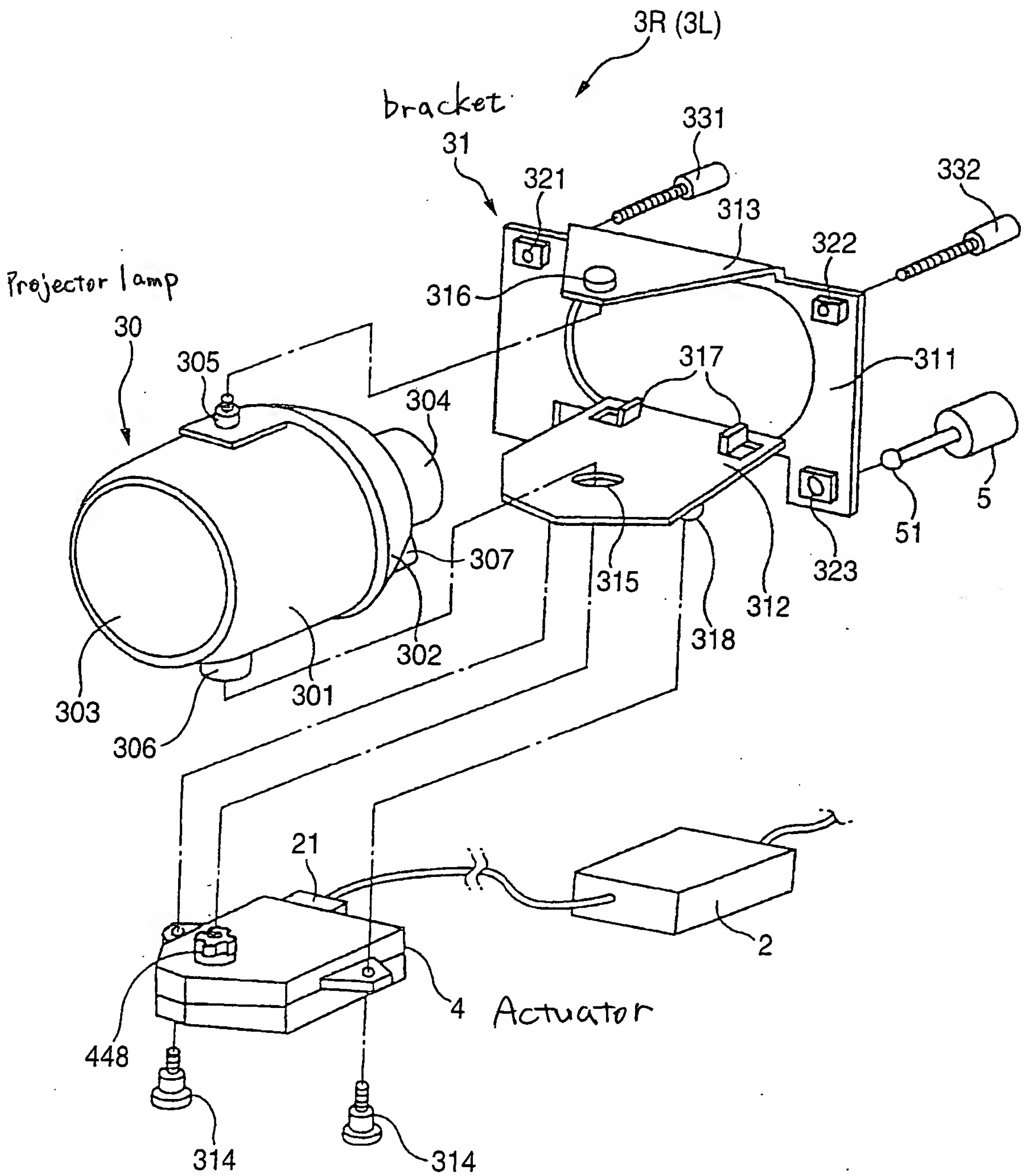
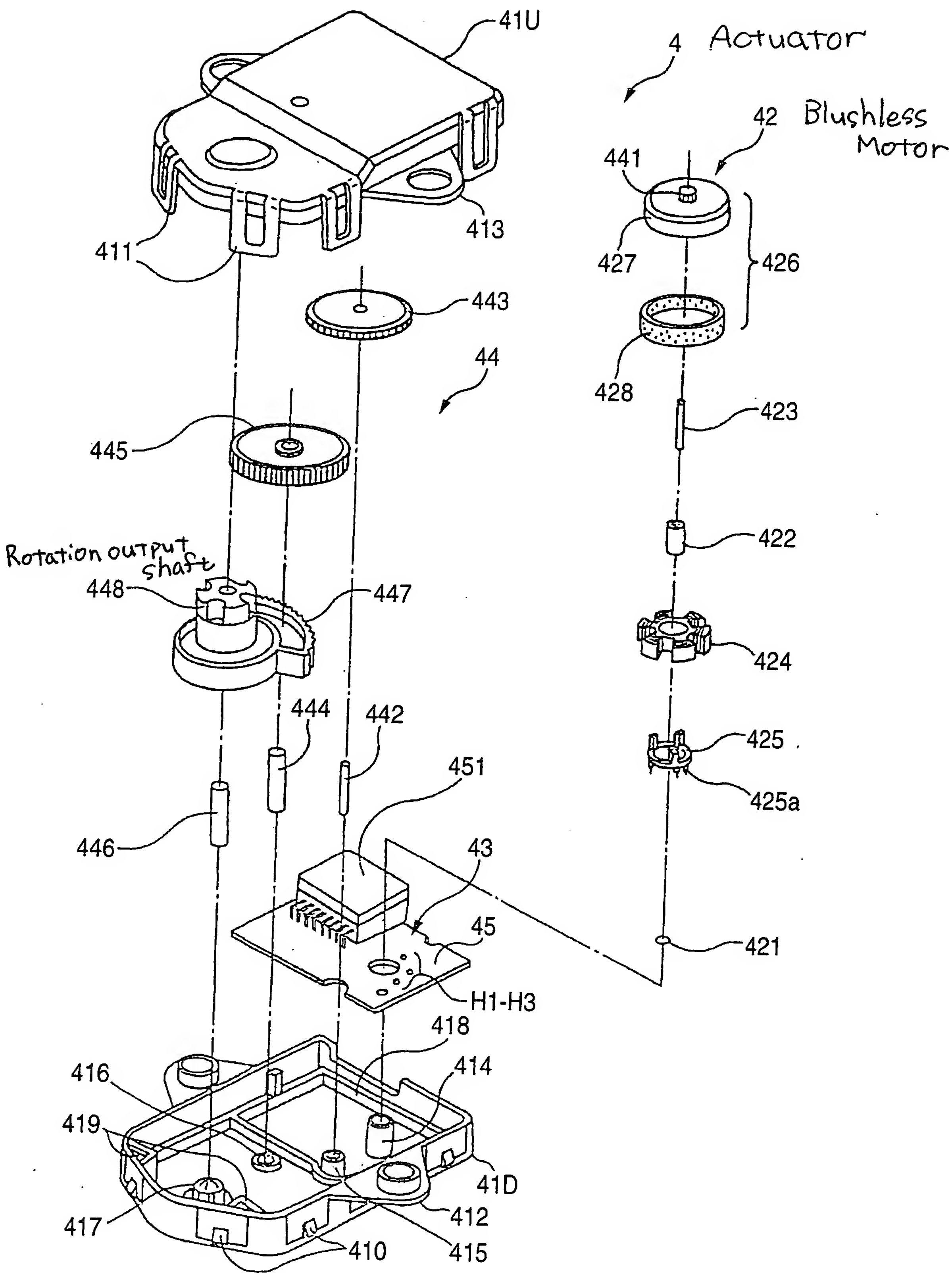

3R (3L)
12
11
Projector Lamp
30
316
313
305
301
302
31
321 (322)
331 (332)
13
14
303
304
306
448
312
21
323
51
5
4
15
16
7 Lighting circuit

FIG. 3



3R (3L)
bracket
31
321
331
313
332
322
Projector lamp
316
30
305
317
311
304
5
307
315
51
323
312
302
318
303
301
306
21
2
4 Actuator
448
314
314

FIG. 4



41U
4 Actuator
42 Blushless Motor
441
411
413
427
426
443
428
44
423
445
422
Rotation output shaft
448
447
424
444
442
425
425a
451
446
43
45
421
H1-H3
418
416
414
419
41D
412
417
410
415

FIG. 5

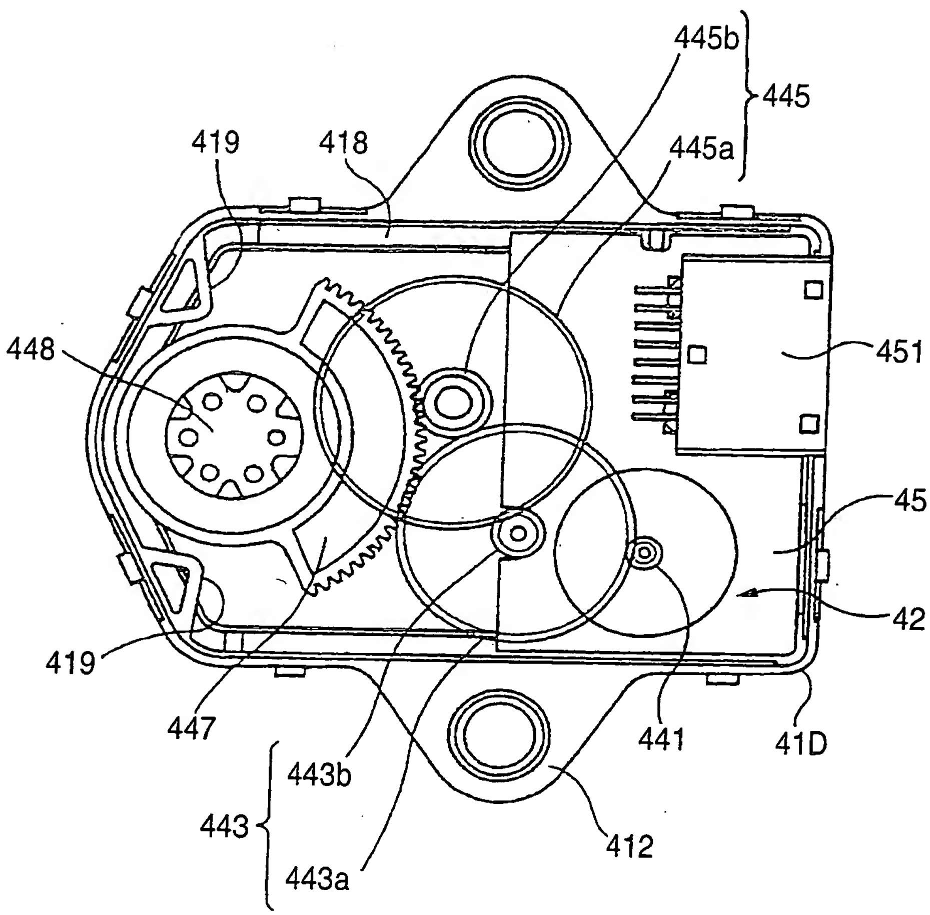
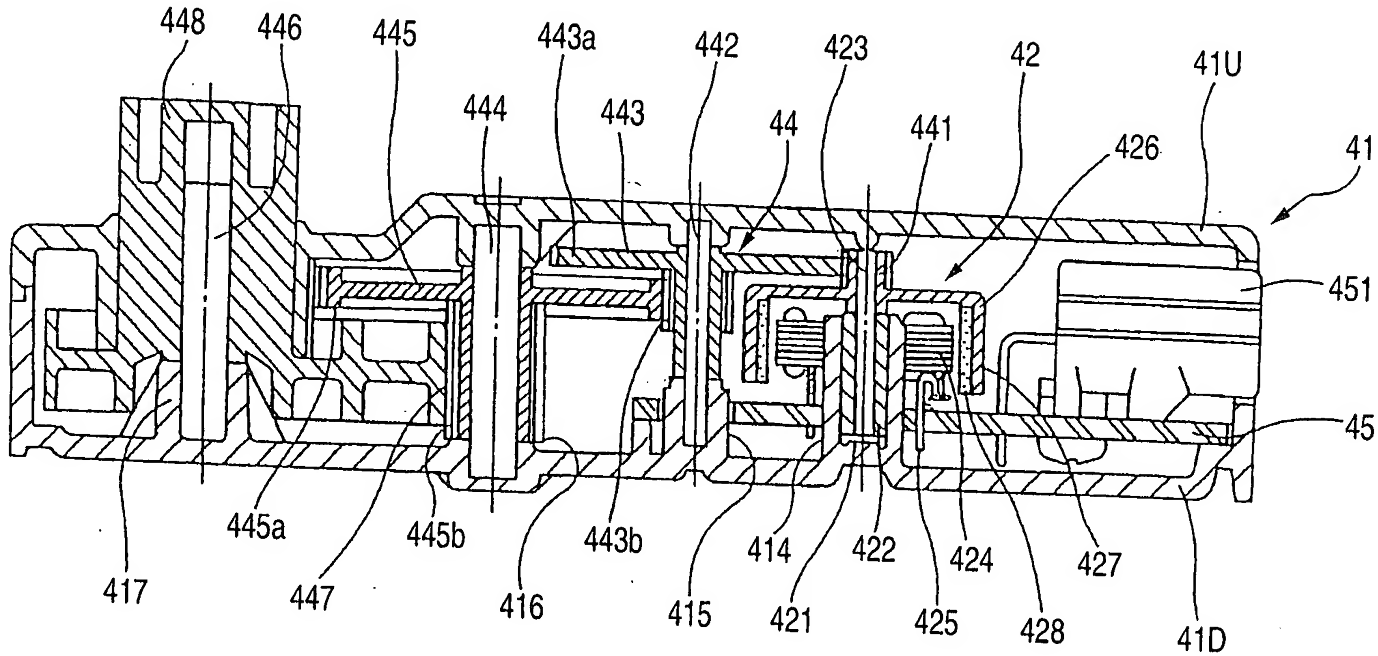
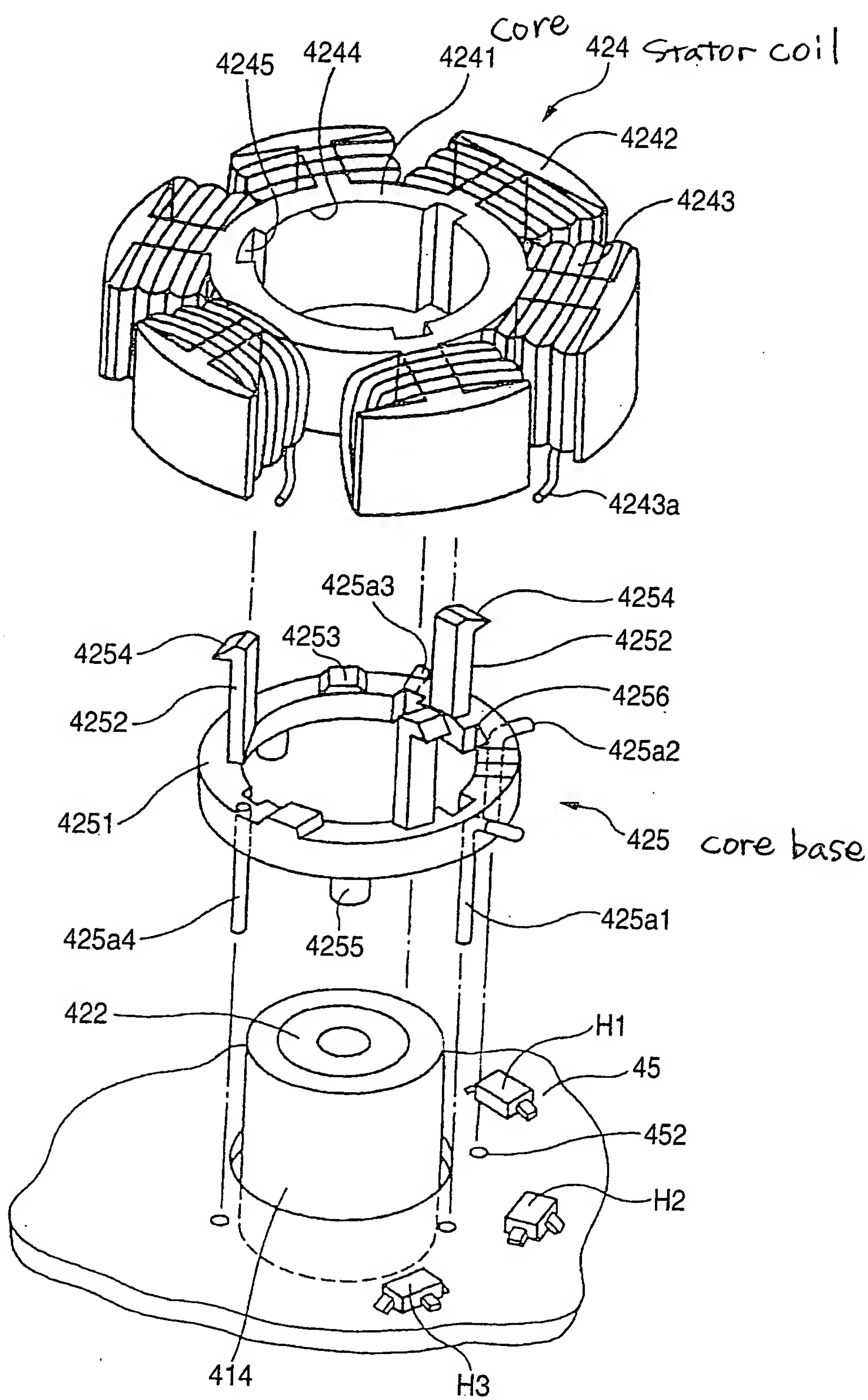

445b
445
445a
419
418
448
451
45
42
419
447
441
41D
443b
443
412
443a

FIG. 6



448
446
445
443a
442
423
42
41U
444
443
44
441
426
41
451
45
417
445a
447
445b
416
443b
415
414
421
422
425
424
428
427
41D

FIG. 7


core
424 stator coil
4245
4244
4241
4242
4243
4243a
425a3
4254
4253
4252
4256
425a2
4251
425
core base
425a4
4255
425a1
422
H1
45
452
H2
414
H3

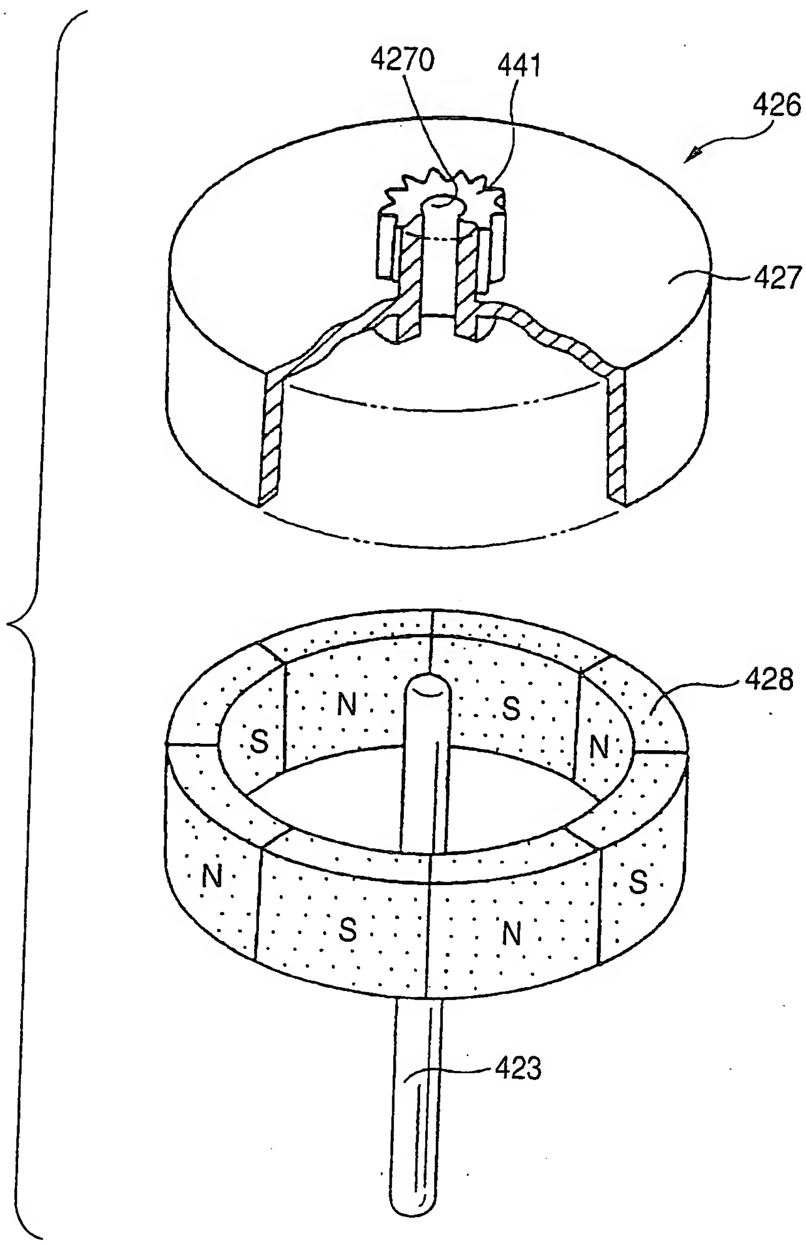
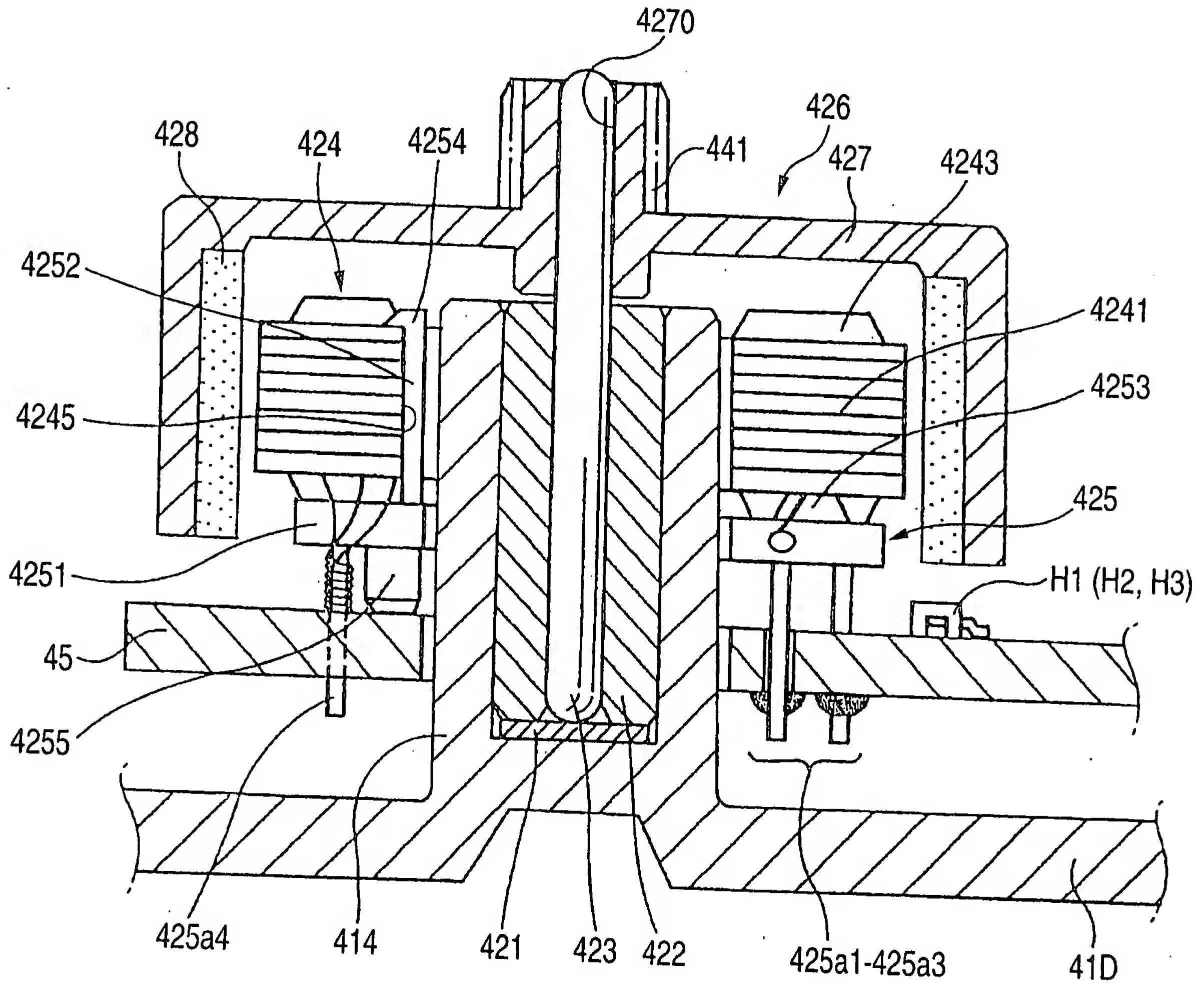


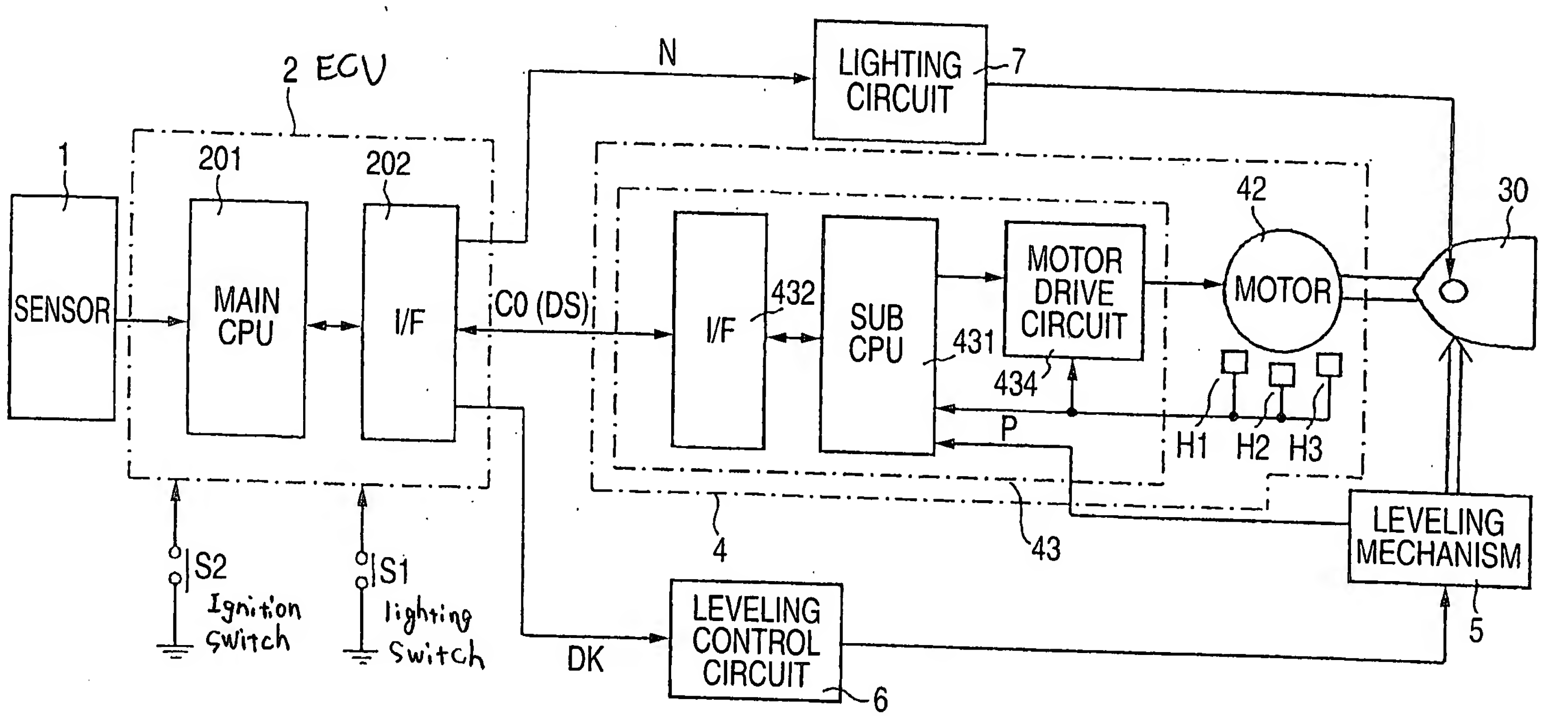
FIG. 8

FIG. 9



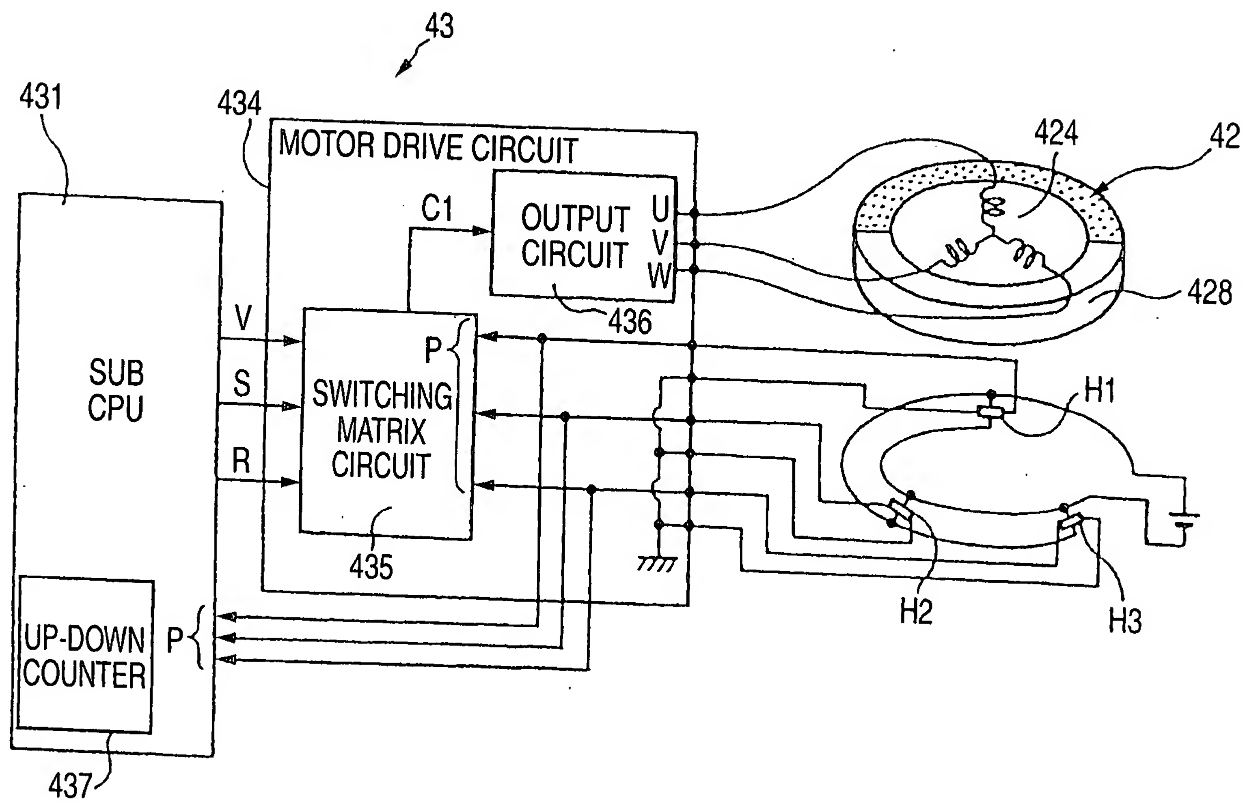
4270
426
428
424
4254
441
427
4243
4252
4241
4245
4253
425
4251
H1 (H2, H3)
45
4255
425a4
414
421
423
422
425a1-425a3
41D

FIG. 10



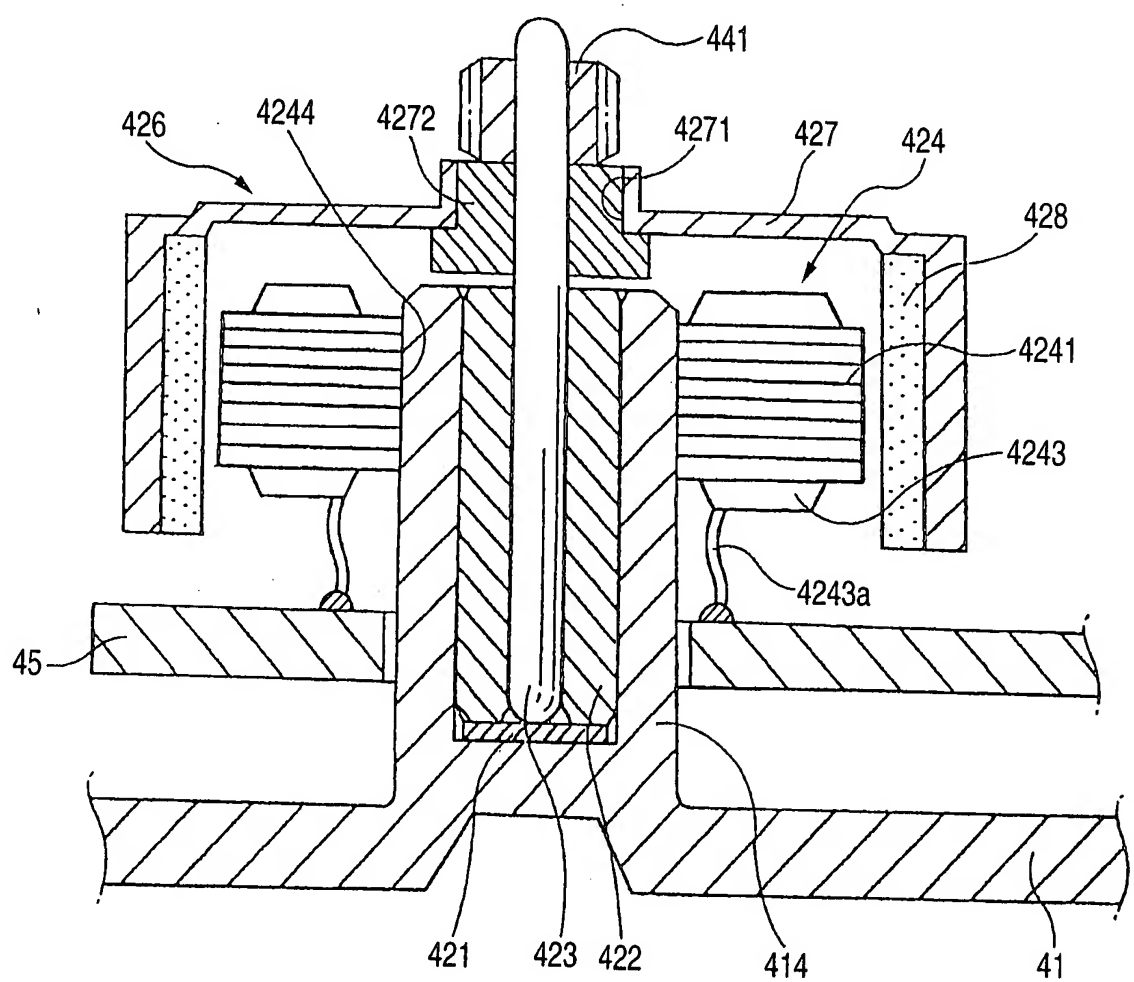
SENSOR
1
2 ECU
MAIN CPU
201
I/F
202
S2
Ignition switch
S1
lighting switch
N
C0 (DS)
DK
LIGHTING CIRCUIT
7
I/F
432
SUB CPU
431
MOTOR DRIVE CIRCUIT
434
P
4
43
MOTOR
42
H1
H2
H3
30
LEVELING CONTROL CIRCUIT
6
LEVELING MECHANISM
5

FIG. 11



43
431
434
MOTOR DRIVE CIRCUIT
C1
OUTPUT CIRCUIT
U
V
W
436
424
42
428
SUB CPU
V
S
R
P
SWITCHING MATRIX CIRCUIT
435
H1
H2
H3
UP-DOWN COUNTER
P
437

FIG. 12



441
426
4244
4272
4271
427
424
428
4241
4243
4243a
45
421
423
422
414
41

FIG. 13